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A SIMPLE APPARATUS FOR ILLUSTRATING THE ABERRATION OF LIGHT

BY JOHN SATTERLY

Many years ago the author, while attending the lectures of Sir Norman Lockyer on Astronomy at the Royal College of Science, London, saw on the lecture table a piece of simple apparatus for illustrating the (astronomical) aberration of light. The same apparatus may, of course, be used to illustrate the theorem of relative velocities and the writer has been surprised to find that little or no mention is made of such an apparatus in text-books or in catalogues of instrument makers.

This deficiency was very apparent to the author when he was lecturing on Light in the University of Toronto. He, therefore decided to remedy it by designing a little apparatus which seems now to be an improvement on Sir Norman Lockyer's and which may be found useful by teachers. Hence this description.

In designing the apparatus the author has received great help from Mr. T. S. Plaskett, of the Physics Department of the University of Toronto, who made it and who is responsible in great measure for the final design. The apparatus was first shown at the annual meeting of this society in February, 1918.

The theory of the aberration of Light is as follows: Suppose a distant star to be sending down light to the solar system along a direction parallel to the line SA, Fig. 1, and the earth to be moving in the direction EA. If we cut off from AS, AE lengths proportional to the velocities of light and of the earth respectively and join ES it follows that an astronomer on the earth wishing to observe the star must point his telescope in a direction parallel to ES and not parallel to AS, the true direction of the star. The case is similar to a man walking briskly along through

a shower of vertical raindrops. He holds his umbrella at an oblique position in front of him. Fig. 1 shows that if light travelling along S, SA arrives at S when the earth travelling along EA arrives at E, the light gets to 1 when the earth gets to a, the light gets to 2 when the earth gets to b, and so on, the light and the earth arriving together at A. The lines ES, a1, b2, c3, d4, e5 indicate the successive positions of a telescope directed by an observer on the earth to receive the star light. The telescope must, therefore, be directed ahead of the star.

The lines ES, AS will coincide only in the case of a stationary observer; in that case the telescope must be pointed directly at the star.

Fig. 1—Diagram showing the velocity of light and of the earth.

From geometry it follows that

$$\frac{\sin \angle \text{ESA}}{\sin \angle \text{AES}} = \frac{\text{EA}}{\text{AS}} = \frac{\text{velocity of earth in its orbit}}{\text{velocity of light through the air}} \quad \ldots\ldots(1)$$

In the important case which occurs when the angle EAS is a right angle the value of the angle ASE is called the *angle of aberration*. Evidently

$$\tan (\text{angle of aberration}) = \frac{\text{velocity of earth}}{\text{velocity of light}} \quad \ldots\ldots\ldots\ldots(2)$$

On account of aberration the fixed stars appear to describe little ellipses around a mean position; Bradley, who was the first to study this phenomenon, showed how the above expression could be used to calculate the velocity of light.

The apparatus I wish to describe illustrates equation 2 above and by a slight alteration of a string serves to give two instances of the use of the equation. The two instances are: (1) When the velocity of the earth is taken equal to the velocity of light; (2) when the velocity of the earth is taken to be half that of the velocity of light. It is the latter that is illustrated in the diagram of the apparatus shown in Fig. 2.

The earth is represented by a little wooden trolley E, about six inches long and two and a half inches wide, running on four small wheels between longitudinal guides RR of which only one is shown in the figure. These guides are fixed to a base board AA, which is about thirty-six inches long and six inches wide. The telescope is represented by a tube, L, of transparent celluloid about thirty-six inches long and two inches in diameter. The celluloid sheet was bent into the form of a cylinder, leaving a long narrow slot on the upper side about three-sixteenths of an inch wide. It is kept in shape by about sixteen slotted brass rings distributed along its length and fastened to the tube by a little shellac. At the lower end the celluloid tube is shallaced into a short brass tube C, to which is fixed a brass disc D furnished with an axis which, passes through a hole in a brass upright G mounted on the trolley. The end of the axis is threaded and a wing nut W is used to tighten D upon G. See Fig. 3 for a sketch of these details.

The vertically falling starlight is represented by a brass ball B hanging from a thread S. This thread passes up over a pulley P_1 clamped to a stand U, down around a pulley P_2 fixed to the bottom of the stand, along the level around a pulley P_3 fastened to the trolley and back along the level to a hook H fixed to the base of the apparatus. It will be seen that the downward velocity of the ball is twice that of the horizontal velocity of the trolley. The ball hangs within the tube, the string passing through the slot, and if the inclination of the tube to the vertical is equal to the angle whose tangent is one-half it follows that as the trolley moves forward the ball passes centrally down the tube and enters the brass cap C, imitating very well a ray of light entering a telescope and passing into the observer's eye at the eyepiece. To pass over to the other instance quoted above when the velocities of the earth and light are equal, the hook of the string is removed from H and hitched into a loop along the bottom portion of the string between P_2 and P_3. This loop is not shown in the figure. At the same time the tilt of the tube is lowered to 45°. To carry out these changes of tilt quickly, the stand G fixed to the trolley has a portion of its upper rim removed (Fig. 3). A projection I fixed to D moves along this hollowed out space when W is loosened and the notch is of such length that when I is at the extreme left the tilt of the

tube is the angle whose tangent is equal to two (*i.e.* about 63½°) and when the pin is as far over to the right as it will go the tilt is 45°. Thus the tube can be clamped quickly in either of these two positions. The size of the notch is the only part of the apparatus that need be accurately adjusted.

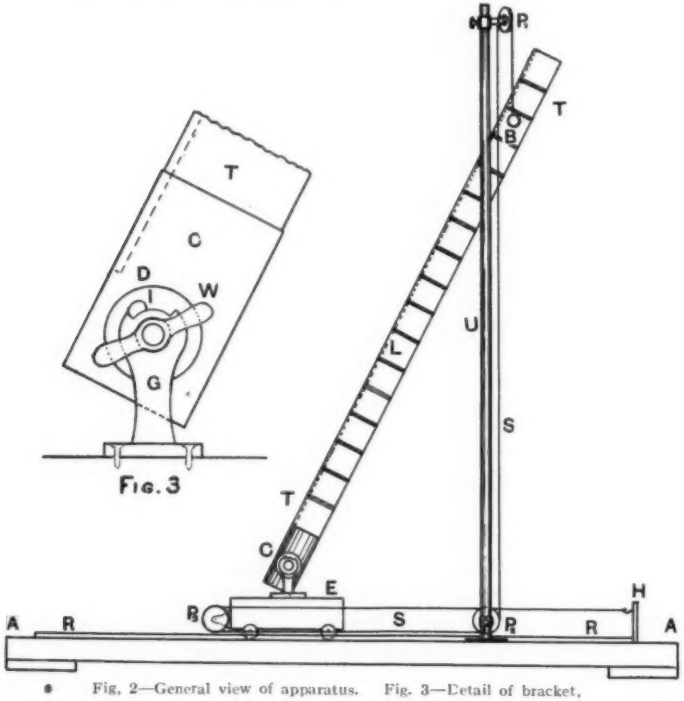


Fig. 3

Fig. 2—General view of apparatus. Fig. 3—Detail of bracket.

To use the apparatus to indicate relative velocity I need only say that if E (Fig. 1) is travelling glong EA with a velocity proportional to EA and S is travelling along SA with a velocity proportional to SA, the relative velocity of S with respect to E is SE in direction and in magnitude proportional to SE. Thus an observer at the lower end of the telescope (Fig. 2) sees the ball travelling apparently directly towards him with a velocity compounded or the two velocities SA and EA reversed.

THE POSSIBLE ROLE OF RADIATION PRESSURE IN STELLAR PHYSICS

By F. Henroteau

THERE seems to be, among astronomers, a widespread opinion that the masses of stars are not widely different from one another (about from one to three times, twenty times being perhaps a limit, the mass of the Sun) and this opinion is not without good foundation. However when we consider the orbits of certain kinds of spectroscopic binaries, such as those of giant B stars or of Cepheid variables, which are nothing else than giant F or G stars, we find that the function of the masses $\frac{m_1^3 \sin^3 i}{(m+m_1)^2}$ is usually surprisingly small. As an example we may give the following table:

Star	*Spectral Class*	$\frac{m_1^3 \sin^3 i}{(m+m_1)^2}$
β Cephei	B1	0.0001 $\odot$
β Can. Maj.	B1	0.00002$\odot$
α Urs. Min.	F8 (Cepheid)	0.00001$\odot$
δ Cephei	G (Cepheid)	0.0036 $\odot$
β Ursae Maj.	A (Cepheid)	0.0003 $\odot$
β Orionis	B8	0.00011$\odot$

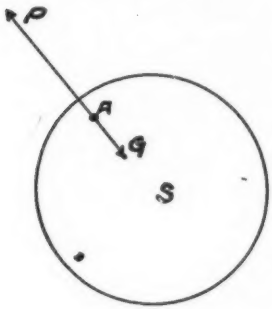
These small values of the mass function would imply that the masses of these bodies are very small fractions of the mass of the Sun, or rather that the components of these binary systems act upon each other as if they had a very small mass. In reality they must be large bodies, especially if we want to reconcile ourselves to the idea that these stars are giant stars, *i.e.*, have an intrinsic brightness of the order of one thousand times the intrinsic brightness of the Sun. (β Canis Majoris is about 1020 times as bright as the Sun). We arrive at this last conclusion by direct measures of parallaxes compared with the measured magnitudes of these stars, while we

arrive at the exceedingly small values of the masses by supposing that the above stars are spectroscopic binaries. A great many astronomers nowadays (one of the first among them being Shapley at the Mt. Wilson Observatory) believe that they are not binaries. However, whether they are binaries, or not, has never been proved.

Two bodies *may have large masses*, but may act upon each other as if their masses were greatly reduced, hence from their orbit we would derive a function of the masses which is entirely fictitious. A good argument in favour of this opinion could possibly be found in the fact that in giant stars, radiation pressure in the core of the body may decrease its apparent mass, or in other words reduce its *active mass*. In favour of this possibility, let us consider Eddington's work on the interior of a star. (See his articles published in the recent numbers of the *Monthly Notices*).

Eddington shows that there are two factors which contribute to the internal equilibrium of a star, first gravitation; secondly, radiation pressure. The influence of radiation pressure, according to Eddington, increases very markedly when the mass of the body increases. If we take indeed a series of globes of perfect gases, the first one containing 10 grams, the second 10^2 grams, the third 10^3 grams and so on, Eddington has computed the ratio of radiation pressure to gravitation for each of these globes. He found that for the first 33 globes (masses from 10 to 10^{33}), this ratio is always less than 1/10. From the 35th globe on, the ratio is greater than 8/10 (being always smaller than unity). It can be seen thus, that the importance of radiation pressure for the first group of spheres, is very small, but that in the second group, it must have a great influence, since it almost neutralizes the effect of gravitation. The transition between the two series of globes is marked by the globe of mass 10^{34} grams, a mass which is approximately equal to the mean mass of the stars. This is very significant; it shows why the matter in the Universe would have divided itself into stellar bodies of approximately the same mass, for according to Eddington's researches, a star would lose its stability if its mass was much superior to the mean mass; the radiation pressure would become too great and gravitation could not maintain its matter in an agglomerated state; if the star mass was much inferior to the mean mass, it could never become incandescent, hence be visible as a star.

Let us now consider a star S and an element of mass in A. This element of mass is acted on by two forces, one AG due to gravitation and directed toward the centre of mass of the star and the other AP, due to radiation pressure, and directed in almost the opposite direction (AP < AG). The pressure of A on the other particles instead of being AG, if we consider the radiation pressure, will be AG−AP. Hence the mutual molecular elasticity of the whole mass instead of being $\int$AG for all the elements of the mass will be $\int$(AG−AP) and the mass although being very great will act as a mass considerably smaller. This consideration would explain the small values obtained for the mass function $m_1{}^3 \sin{}^3 i/(m+m_1)^2$ in the stars like β Canis Majoris. It would also explain that enormous nebulae, like the Orion nebula, do not exert any attraction (at least any apparent attraction) on the stars of the Universe. With the conception of gravitation which prevailed up to now, we have to suppose that the density of the Orion nebula is exceedingly small (too small to be conceivable), otherwise the mass of this nebula would be so great that it would attract and absorb all the stars of the Universe. This would happen even if the density of the gases in the Orion nebula were of the same order as that of rarefied air in Crookes tubes.



From observationa' data, we have then to consider enormous bodies with an exceedingly small active mass, bodies which have an exceedingly high absolute brightness, of the order of hundreds of times the absolute brightness of our sun. Would it not be possible in this case that the radiation pressure emanating from these bodies would have an enormous influence on other bodies, influence which might perhaps be as great as that of gravitation? Let us endeavour to prove this by a small computation and propose the following problem: What is the value of the attraction due to gravitation and of the radiation pressure exerted by a giant star such as a Cepheid or certain class B stars? Let us treat the problem in two parts.

(1) *How great is the attraction due to gravitation?* We have:

Volume of earth $= 1083260 \times 10^{6}$ cubic kilometers
$= 1083260 \times 10^{21}$ cubic centimeters
Mass of earth $= 1083260 \times 5.527 \times 10^{24}$ grams
But Mass of Sun $= 332000 \times$ mass of earth
$= 108326 \times 5.527 \times 332 \times 10^{6}$

But the mass of a Cepheid variable (or of a giant star of the type described above), may be considered according to actual data as being

$$= \text{mass of Sun} \times 10^{-5};$$

for in a case like α Ursae Minoris (taking an example) the value of $\frac{m_1^2 \sin^2 i}{(m+m_1)^2}$ is 0.00001. If now $\sin^2 i = 1$ and if $m = m_1$ we have

$$m_1/4 = 0.00001$$

hence an *active mass* of even $10^{-5} \times \odot$ could possibly agree with these facts.

The mass of such a Cepheid would then be

$$108326 \times 5.527 \times 332 \times 10^{23},$$

or, to make figures simpler

$$5 \times 10^{30}.$$

The attraction exerted from such a star on another star of the same mass (at one unit distance) would then be

$$f = G \times M^2$$

with $G = 6.658 \times 10^{-8} = 67 \times 10^{-9}$

hence: $f = 67 \times 10^{-9} \times 25 \times 10^{60}$
$= 67 \times 25 \times 10^{51}$ dynes

or if the mass of the second body is much smaller (which is very likely) an attraction due to gravitation at a distance of 1 cm. of 10^{51} dynes would certainly not be out of proportion.

(2). *How great is the repulsion due to radiation pressure?*

According to the computations of Dr. Klotz, the pressure of the radiation of the whole sun on a square cm. of surface situated at a distance equal to its radius is 2.8 dynes. The radius of the sun is $69{,}717 \times 10^{6}$ cm.; so the pressure of the radiation of the whole sun on 1 sq. cm. of surface at a distance of 1 cm. will then be

$$2.8 \times (69717)^2 \times 10^{12} \text{ dynes.}$$

As a giant star may be considered as being about 1,000 times brighter than the sun, its radiation pressure on 1 sq. cm. at 1 cm. distance would be about

$$3 \times 70000)^2 \times 10^{15} \text{ dynes,}$$
$$= 3 \times 7^2 \times 10^{23} \text{ dynes,}$$

or a little greater than 10^{25} dynes.

The radiating surface of a body like the sun would be

$$\pi R^2 = \text{about } 3 \times 70000^2 \times 10^{12} \text{ cm.}$$
$$= 3 \times 7^2 \times 10^{20} \text{ c.c.}$$

The radiating surface of a giant star may be considered about 1000 times the preceeding value or

$$3\times7^2\times10^{21}$$

or about 10^{25} sq. cm.
A radiation pressure is then exerted on this surface of

$$10^{25}\times10^{25}=10^{50} \text{ dynes.}$$

Conclusion.—So, according to the data of observation the pressure of radiation might be of the same order as the attraction due to gravitation.

Besides, there seem to be in connection with giant stars, many problems which necessitate the intervention of a physical force. Among them is the problem of Cepheid variables in which we have found regular secondary oscillations (which cannot be explained by the supposition of a triple system) and the problem of very short early class B spectroscopic binaries, without mentioning any others. Let us discuss these two problems separately.

(1). *The secondary oscillations in Cepheid variables.* It was found in certain Cepheid variables, that the curve of radial velocity variation does not always indicate a simple elliptic motion, but is complicated by a secondary oscillation whose period is the same as or is an exact fraction of the period of the primary oscillation. The two most striking examples of such variations are those of ξ Geminorum studied by Dr. W. W. Campbell and W Sagittarii studied by Dr. R. H. Curtiss (see *Lick Observatory Bulletins*). The latter has discussed these cases very thoroughly (see *Detroit Obs. Publ.*, vol. I., p. 113) and tried to explain the peculiarities of the velocity curve by the combination of two effects, the first one, an orbital velocity and the second one, a rotational velocity. However he finds it difficult to explain the facts very well. Perhaps in such cases, a combination of an orbital motion due to gravitation and an orbital motion due to light pressure would give us a simpler explanation. The case would theoretically be of great interest. For gravitation the attraction would be inversely proportional to the square of the distance; for radiation pressure it would be a more complicated function, since the action is mostly from a radiating surface on another absorbing surface. It seems however that the curve of velocity variation would be periodical and that the problem would not show all the difficulties of a three body system.

(2). *The very short period early class B spectroscopic binaries.* These stars can be divided in two classes: (1) those of the type of σ Scorpii; (2) those of the type of β Canis Majoris or 12 Lacertæ. The first ones act like triple systems, and the second ones act as if they had a velocity curve of variable amplitude, or were the combination of two oscillations of very short period but slightly different in lengths. The radial velocity curves in both these classes seem then always to be the combination of two oscillations. Especially when these two oscillations are of very short duration it seems to be rather difficult to attribute at least one of them to gravitational action and its source must then be sought in some kind of physical attraction or repulsion of which one of the simplest ones we can imagine is radiation pressure.

DOMINION OBSERVATORY, OTTAWA,
December 22nd, 1919.

THE FESTIVAL OF THE DEAD

By R. G. Haliburton

(*Continued from page 69*).

Rivero tells us that in November took place the termination of the year and of seed-time. Garcilasso[14] bears distinct testimony to the existence of a traditionary year of seasons.

"Yet, for all this sottish stupidity, the Incas had observed that the sun accomplished its course in the space of a year, which they called *huata;* though the commonalty *divided it only by its seasons,* reckoning their year to end or be finished with their harvest" (*i.e.,* in May).

Here we have the year ending with the months of November and May, a plain proof that the Southern year of the Pleiades ending in November and May, must have existed there before the Incas invented or introduced the solar year, and must have been the seasons referred to by Garcilasso. As the festival of the dead is, however, the new year's festival of the year of the Pleiades, we may assume that it must have, in Peru, originally marked the commencement of the year at the beginning of November. Wherever the festival of the dead occurs in November, even among nations now far north of the equator, the same inference may, I believe, be adduced. The race by whom it is preserved must have once regulated that festival in November, by the rising of the Pleiades, like the Australians and the Pacific Islanders.

In Persia, we find a singular light thrown on the calendar by the festival of agriculture and of death celebrated south of the equator. In the ancient calendar, November was consecrated to the angel who presided over agriculture and death. We have seen that the month in which this festival occurred in Peru, was called "the month of carrying corpses." The month of November was formerly called in Persia Mordad, the month of the angel of death. In spite of the calendar having been changed, the festival of the dead took place at the same time as in Peru, as a new year's festival (although the year no longer commenced then). It is called by some writers the *Nouruz of the Magi,* because the Magi still adhered to the primitive new year's festival.[15] It commenced in the evening with a Halloween, which was regarded as peculiarly sacred. Unde hujus diei *Vespera* quibusdam Persarum, peculiari nomine signatur Phristâph.[16] Bonfires are lighted at this festival as they are in Britain, and in most portions of the globe, at this season of the year.[17]

In Ceylon, Sir Emerson Tennent says, a festival is held that is a species of a harvest home and a commemoration of the dead. It must, however, be rather a first fruits celebration, like that of

[14] Book II, ch. xi. Garcilasso says the harvest time was in March; but Rivero (p. 132) places it in May.

[15] Rel. Vet. Persarum, 238.

[16] Id. 237.

[17] Id. 249.

nations south of the equator, as the harvest is over in May or June. This festival of agriculture and of death takes place at the beginning of November.[18]

We now turn to Mexico, and there we find that the great festival of the Mexican cycle was held on the 17th of November, and was regulated by the Pleiades. It began at sunset; and *at midnight* as that constellation approached the *zenith*, a human victim, Prescott says, was offered up to avert the dread calamity which they believed impended over the human race. This belief[19] was so remarkable that I cannot omit a reference to it here. They had a tradition that at that time the world had been previously destroyed; and they dreaded lest a similar catastrophe would, at the end of a cycle, annihilate the human race.

Now it is most remarkable to find that the Egyptians, with their Isia, or new year's festival of agriculture, and of the dead, that took place on the 17th day of November, associated traditions as to the deluge, and it is still more surprising to find that the 17th day of November is the very day on which, the Bible tells us, the deluge took place.[20]

Greswell has devoted several chapters, and much learning, to the 17th day of November (Athor),[21] to show how remarkable a landmark it has always been, through a long lapse of centuries, for the corrections of the Egyptian calendar, and he derives from it some curious arguments in support of his views. De Rougemont and other writers have referred to this day, but have thrown

[18] Tennent's Christianity in Ceylon, 202, 228. Forbes' Ceylon, 2, 322. See The Mahavansi, translated by Upham, iii. 164.

[19] Prescott's Conq. of Mexico, I., b. 1. ch. iv.

[20] While the above was going through the press, as I was convinced that the memory of the deluge had been thus preserved among the Hebrews, Egyptians, Greeks, and Mexicans, in the traditions connected with the new year's festival, and that the date of the commencement of the deluge, the 17th day of the first month of the primitive year, was not of an historical but of an astronomical character, I more closely examined the Mosaical account of the deluge, and found my conjecture singularly verified. The deluge commenced on the 17th of the second month of the Jewish year (*i.e.*, November); the ark rested on Mount Ararat on the 17th day of the 7th month; and the dove returned with the olive branch on the 17th day of the 11th month. Though the connection of this with the traditions and calendars of heathen races is somewhat startling, I am convinced that should the study of *Ethology* afford a clue to the primeval origin of pagan idolatry, it will at the same time conclusively prove how entirely different and distinct must have been the source from which the Hebrews derived the great truths and principles of our religion.

[21] Those wishing to examine into these points will find the following references bearing on them:—Greswell's Fasti Catholici, i., 82, 152, 154, 168, 181, 196, 198, 200, 225, 228, 229, 343, 356; ii., 104, 115, 226; iii., 88, 89, 112, 113, 131, 160, 166, 330, 405, 407, 413, 416; iv., 173, 610. See Origines Kalendariæ Italicæ, i., 344, 348, 351 to 390, 423, 430; iii., 33, 460, 516.

no light upon it. They seem, however, not to have observed that even among the Persians the same day was peculiarly venerated. Hyde says that in the ancient Persian calendar the 17th day of November was held so sacred, that all favours asked of rulers were granted on that day;[22] but why it was so venerated he does not attempt to conjecture. Even tradition has been unable to preserve the history of this day; that must be sought for in the very earliest ages of the world, or among the rudest existing types of man. In the mysteries of Isis, the goddess of agriculture and of death, the funereal part of the ceremonies, the lamentations and search for Osiris commenced on the 17th and ended on the 19th. There was also a Julian year of the Egyptians, which commenced, Greswell says, on the 18th of November.[23]

Herodotus tells us, that Isis is the same as the Greek goddess Ceres, who, with her daughter Proserpine, presided over agriculture and the dead.[24]

Among the Greeks, besides existing in other ceremonies, the primeval festival of the dead appears under a veil of mythology in all the ancient mysteries, but above all in the greatest of them, the Eleusinian. The Attic Anthesteria and the Roman Feralia were funereal celebrations, and held on the 17th, 18th, and 19th of February. We may therefore assume, that as the lesser Eleusinian mysteries, which were sacred to Proserpine alone, were celebrated in that month, they were held on these ill-omened days.[25]

The Macedonians retained the primitive year beginning in November.[26] It is peculiarly interesting to note that with the festival of the dead, the tradition as to the deluge was also transferred by the Athenians to the 17th day of February. Even in some

[22] See Rel. Vet. Pers., p. 243.

[23] Fasti Cathol., iv. 180.

[24] It is interesting to note how they were connected together. The dead were called Demetriakoi, or belonging to Ceres; while the name of Proserpine means the bringer of fruits. They were evidently originally one deity, presiding over the festival of agriculture and the dead. See Müller's History of the Dorians, translated by Tuffnell and Lewis, ii. 405.

[25] According to Ouvaroff, they were more ancient than the Greater Mysteries, which were literally devoted to *mourning*, as they were consecrated to Achtheia (the Goddess of "*Grief*"). See Lempriere v. "Eleusinia."

Most writers agree that Thesmophoria, which were sacred to Ceres and Proserpine, were borrowed from the Isia. They were held for *three* days, and according to Plutarch, at the same time as the Isia, "when the Pleiades were most distinct." See Ouvaroff on the Mysteries, sec. iii., p. 36 to 38. Gebelin, Le Monde Primitif, iv. 347, 349. Fasti Cath., i. 178 to 181; iii. 112, 160. Orig. Kal. Ital., i. 423 to 429.

[26] See as to the commencement of the ancient year, Clinton's Fasti Hellenici, 355, 364, 366, 618.

other months, the 17th seems to have been a conspicuous day in the Greek calendar. In Persia, in every month, there were three days of fasting and sadness; but as the 17th and 18th days were *dies nefasti*, on which no work was done, we may assume that the 19th was the *ultima dies placandis manibus*, and that the 17th, 18th, and 19th were the days of mourning.[27] In Europe, Asia, and Africa, we find days in every month consecrated to the memory of the dead.

Let us now look south of the equator for an explanation: 1*st*, Why the 17th, 18th, and 19th of the month were so funereal. 2*d*, Why the primitive year of the Egyptians and of other races, and their funereal mysteries, once began on the 17th day of the month. 3*d*, Why, not only at every new year's festival, but even monthly, the dead were commemorated.

Almost all savage races, like all nations of remote antiquity, regulate their months by the new or the full moon, and hold festivals of a funereal character at the time of the new moon, or when the nights are darkest.

The Australians not only hold an annual corroboree of the Pleiades, but also a monthly corroboree of the moon, apparently connected with a dread of ghosts, or a worship of the dead. They regulate their months by the full moon. The Hindoos offer in every lunar month, on Mahacala, the day of the conjunction, and defined as "the day of the nearest approach to the sun," "obsequies to the manes of the *pitris*, or certain progenitors of the human race, to whom the *darker* fortnight is *peculiarly sacred*." Sir William Jones also says, referring to a Hindoo work, "Many subtle points are discussed by my author concerning *the junction of two*, or even *three lunar days in forming one fast* or *festival*."[28]

The Chinese, the Africans, the Caribs, and other races of America, the Greeks, the Romans, and almost all ancient nations, kept a commemoration of the dead in the dark nights of the moon.[29]

Here we have an explanation for a monthly commemoration of the dead, but why were the 17th, 18th, and 19th[30] days of each month, among some races, especially of a funereal character? Ellis tells us that the Society Islanders regard the 17th, 18th, and 19th nights of the moon, as seasons "when spirits wander more

[27] Hyde, Rel. Vet. Pers., p. 230, 232, 248, 262.

the full or the new moon, were evidently regarded as peculiarly

[28] Sir William Jones' Works (ed. 1807), vol. iv., p. 129.

[29] De Rougemont, Le Peuple Primitif, ii. 246, 263, 355. Boulanger, i., 269 to 297, 301. Horace, Odes, iii., 23.

[30] See Fasti Cath., iii. 160.

than at any other time,"[31] a plain proof that even among the Pacific Islanders, three days, in every month, must have been consecrated to the dead, as to this day, it is still believed in Britain, that on Halloween, when the festival of the dead once commenced, "the spirits of the dead wander more than at any other time of the year." "This is a night when devils, witches, and other mischief-making beings, are all abroad on their baleful midnight errands."

But the question arises, How came the beginning of the year to be, among some nations, on the 17th day of the month? The explanation, I think, is plain. The Chinese, the Hebrews, and other races, regulated the beginning of the year at the time of the new moon, *i.e.*, at the time of the festival held in the dark nights of the moon. With many races, the 17th, 18th, and 19th days after the full or the new moon were evidently regarded as peculiarly sacred to the dead, and were the monthly days of rest or the monthly *sabbath* of heathen races.

Our own mode of regulating Easter, will serve to explain the commencement of the ancient year. The Common Prayer-book says: "Easter-day is always the first Sunday after the full moon which happens upon or next after the 21st day of March." But the Hebrews probably substituted four sabbaths in place of one monthly time of rest, and used the vernal equinox, instead of the rising of the Pleiades, to regulate their Passover. Let us substitute the monthly festival of the dead for the word Sabbath, and the rising of the Pleiades for March 21, and we read, "New Year's day is always the monthly sabbath, which happens upon or next after the culmination of the Pleiades at midnight." But as this would occur near the month of November, we can understand that when the months ceased to be lunar, and their festivals "moveable," the new year's festival would, for some time at least, continue to be held on the 17th day of the first month, and that the 17th, 18th, and 19th days of every month would still appear in ancient calendars as funereal days. We can also understand that a traditionary veneration for the 17th day of the month, especially of November, would long continue, like some old sea-margin, to show the changes which time had effected; and that the new year's festival of the dead, preserved in the mysteries of Isis, would long be held on the 17th, 18th, and 19th nights of the first month of the primitive year, though no longer those dark nights of the moon, in which the spirits of the dead are wont to wander forth from their

[31] Ellis' Polynesian Researches, i. 88. If the Society Islanders commenced the month at the new moon, the nights peculiarly consecrated to the dead, would be the light nights, instead of the dark nights, of the moon. If their month began at the time of the full moon, the 17th, 18th and 19th would be the three dark nights succeeding the new moon, and would correspond to those devoted in Hindostan, and in many other countries, to a commemoration of the dead.

Maraes and their temples to receive the offerings of their trembling worshippers.[32]

Among the Romans we find a trace of a partial observance of the festival of the dead in November.[33] They seem, however, to have borrowed their Feralia or festival of the dead, from the Athenian Anthesteria, as they were both held on the 17th, 18th, and 19th of February.[34] The more ancient institution was the Lemuria, or festival of the ghosts, celebrated in May—a month, therefore, so unlucky that no marriage took place in it. Ovid and Greswell both agree as to the antiquity of the Lemuria. It is evident that this festival, transferred from November to May, was originally regulated by the heliacal rising of the Pleiades in the morning. Yet the offering to the spirits took place at midnight, a time when that constellation was invisible. What can have made that hour so peculiarly marked?

"Non hæc Pleiades faciunt, nec aquosus Orion."[35]

Greswell connects this circumstance with the November festival of the Aztecs, which *commenced in the evening*, and in which *midnight* was the hour of sacrifice. From this he infers that the calamity commemorated was the event of the sun going back ten degrees in the days of Hezekiah. His remarks as to the Aztec festival supply a clue to the fact that the Lemuria must have been moved from November to May, from the month when the Pleiades rose in the evening and culminated at midnight, to May, when they were invisible till early dawn[36]; and above all, they will prove

[32] Wherever we find the festivals of a nation, especially those of a mournful or funereal character, occurring on the 15th, 16th and 17th, or on the 17th, 18th and 19th days of the month, there is strong reason to assume that the month must have originally commenced, not with the new, but with the full, moon. Among the Hindoos both systems are in vogue. See on this point Greswell's Fasti Catholici, i. 62. Sir William Jones' Works, iv. 128.

[33] Sauberti de Sacrificiis, 89.

[34] Orig. Kal. Ital., i. 303, 423, 430.

[35] Propertius, ii. 16, 51.

[36] "The ceremony of the secular fire among the Aztecs, the oldest, the most solemn, the most sacred of all in their calendar, seems to imply the same thing of them; for that was celebrated at midnight; that is, though the ceremony itself *began at sunset*, the consummation or conclusion, by the lighting anew of the secular fire, took place *at midnight*. The primitive rule of the cycle" (the noctidiurnal system, the day commencing in the evening) "and a co-ordinate rule borrowed from midnight, seem both to have been associated in this one ceremony.

"We have very little doubt indeed that, were the truth known, both the ceremony of the secular fire, and the change of the rule of the noctidiurnal cycle (if it must be so called) among these nations, would be found to be ultimately due to the miracle of B.C. 710, and to the circumstances under which it took place among them and to the effect which it produced on their fears and apprehensions." But the connection of the Pleiades with

that a miracle should be the *dernier ressort* of a philosopher, and that he should be the last to consider "omne ignotum pro merefico."

Before concluding this necessarily superficial sketch of this primeval new year's festival, a subject respecting which scores of volumes might be written, I must turn to Britain to see if we have among us any traces of this primitive year, or seasons of the Pleiades. That it did exist among the Celtic race,[37] has long been known to those who have studied its history and customs. Wylde says, "the first great division of the year was into summer and winter, Samradh and Geimradh, the former beginning in May or Bealtine, and the latter in November, the Samhfhuim, summer end. On the first of May took place the great Druid festival of Beal or Bel, and at the beginning of November, All Halloweven;"[38] and it is strange that both the eve of May day, and Halloween, are ill-omened nights, on which prudent persons in Ireland, from fear of encountering fairies and ghosts, avoid being out after dark.[39]

Classical writers of antiquity tell us that in Britain, Ceres and Proserpine were worshipped in the same manner as in the mysteries of the Cabiri. Now we have seen that Proserpine and her mother Ceres, are really the same deities, both being connected with agriculture and the dead. In Sicily, Ceres was worshipped in May, and Prosperine in the autumn.[40] The latter was called

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the Aztec festival seems to have somewhat puzzled Greswell. *"We recommend this point to the notice of astronomers.* The fact is certain that *the culmination of this particular constellation was one of the phenomena presented by the heavens, to which the Aztecs in particular, for some reason or other, looked with particular interest, and attached peculiar importance.* It was associated with the ceremony of the secular fire, and apparently from the first; the moment prescribed for the offering of the stated sacrifice, followed by the rekindling of the extinguished fires (destined to last another secular period of 52 years), being precisely that when the Pleiades were in the middle of the sky."—Fasti Catholici, i. 362; as to Lemuria, p. 356; also see rising of stars being reversed, p. 343.

[37] Wylde's Irish Popular Superstitions, p. 38.

[38] That Hallowe'en was not only a funereal, but also an agricultural, festival, is perfectly clear. Associated in Britain with a harvest home, the *Kernbaby*, or Cornbaby, must have once been one of its features. The following passage is in point:

Shaw, in his History of the Province of Moray, p. 241, says: "A solemnity was kept on the eve of the 1st November, as *a thanksgiving for the safe ingathering of the produce of the fields.* This, I am told, but have not seen it, is observed in Buchan, and other counties, by having *Halloweve fires* kindled on some rising ground." Brand's Pop. Ant., 388.

[39] See Wylde, 52 to 58; Brady's Clavis Calendaria; also Brand's Popr. Antiq., i. 380.

[40] The marriage of Proserpine, who was "in autumn wed," must have been almost simultaneously celebrated with that of the Core of the South. But the myth of the appearance and disappearance of Proserpine merely

Core, or the damsel. Are there any traces of her still in Britain? It is manifest that the May queen, and the Kernbaby of the harvest home, are either relics of this deity, or the origin of the myth. But we have evidence that they are as old, if not older, than Proserpine herself. In the Tonga Islands, at a first fruits celebration, a child presides as a sort of Southern queen of the spring, a November queen, if I may give her a new title.

The Tow Tow, a species of first fruits celebration, takes place "at the time when the yams are approaching maturity, *in the early part of November,*" when prayers are offered up to A'lo A'lo, the god of weather. Mariner, in describing it, says, "A deputation of nine or ten men from the priests of A'lo A'lo, all dressed in mats, with green leaves round their necks, arrives with a female child, to represent *the wife of A'lo A'lo.*"[41] They offer up a prayer for a fruitful season to the god, and then divide the provisions collected for the occasion. One pile being assigned to A'lo A'lo, and to other gods. Mariner tells us that "she is selected from the chiefs of the higher ranks, and *is about eight or ten years old;* during the eighty days of this ceremony, she resides at the consecrated house of A'lo A'lo, where, a day before the ceremony, a cava party is held, at which she presides, as well as at a feast which follows. She has nothing to do on the actual days of the ceremony, except to come with the deputation and to sit with them." Here, then, we have, south of the equator, a "queen of the May," or a *Kernbaby,* whichever we may call her. But in China, Core, or the damsel, assumes more distinctly the funereal character of Prosperine.[42] At the festival of the dead, a child presides,

typified the appearance and disappearance of the Pleiades. For three days at the Thesmophoria Ceres mourns for her daughter, who for six months is visible on earth, and for the rest of the year is compelled to reign with Pluto in hell. Dupuis shows clearly that the story had some reference to Taurus. But as Ceres was comforted by *Hesperus,* and by *certain stars* seen by her *in the evening,* the appearance of Proserpine must originally have meant the beginning of "the Pleiades above," which commenced when those stars were first visible at the horizon in the evening. In November the great festival of the Pleiades is still celebrated by the Australians. The fact that there was a temple in Sicily in which Ceres, Proserpine, and the Pleiades were jointly worshipped, confirms my view of this strange myth. (Dupuis V. 270; IX. 340; Ov. Fast. IV. 536. Callim. Hymn. in Cererem.)

[41] Mariner's Tonga Islands, 385.

[42] Since writing the above I have met with a very interesting confirmation of my views. Callee, the Hindoo Core, "who appears," says Sir William Jones, "in the *calijug, as a damsel twelve years old,*" presides over a festival of the dead at the beginning of October. She wore a necklace of golden skulls, descriptive of the dreadful rites in which she took so gloomy a delight." The offerings which were described by the Vedas were human sacrifices, for which, however, bulls and horses were substituted. Soul

who receives the offerings made to deceased ancestors.[43] In the South, she is the wife of A'lo, the god of weather, but in Grecian mythology, she is "in autmun wed"[44] to Pluto, the god of the dead; and in Egyptian fables, she is doomed, at the November festival of the new year, to mourn Osiris, the God of Agriculture and "the Lord of Tombs." It would be strange, if, in the half-naked little Feejee savage, the wife of A'lo, we should find a clue to her, who was "the ancient goddess" in the days of the Patriarchs, and whose statues bore the inscription, "I am all that has been, that shall be; and none among mortals has hitherto taken off my veil."[45]

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cakes are also consecrated to her, as they were to Proserpine in Greece, as the deity presiding over the dead.

Our soldiers found at Cawnpore an ode invoking "the black Goddess," the cruel Callee, written by Nana Sahib before the outbreak. The soul cake, the symbol of revolt among the Hindoos, was the emblem of this bloody godess; and there can be but little doubt that the slaughter of our unhappy countrymen was regarded by the fanatical Sepoys as a welcome offering to their sanguinary deity. If any of her victims had ever in their native land been at a rustic "maying", or harvest home, how little could they have dreamed, as they looked at the May Queen or the Kernbaby, that they saw before them the primitive type of a cruel deity, at whose altar they were doomed to be sacrificed! See Sir William Jones' Works, iv. 185. Maurice's Indian Antiquities, ii. 181. Hardwicke, the late Christian Advocate at Cambridge, is strangely in error on this point; see "Christ and our other Masters," part ii. page 19. See as to worship of the dead, iii. 32, 125, 176, 196; iv. 78.

[43] De Rougemont, "Peuple Primitive," ii., p. 356.

[44] See Orphic Hymn to Proserpine.

[45] Exhibiting a funereal and agricultural character, the ancient mysteries were, as we have seen, clearly connected, by their very time of observance, with the new year's celebration of the South, the festival of first fruits, and of the dead. But even their obscene rites and their peculiar secrecy may be solved by a reference to the savages of Australia and of Central Africa. Europeans who have been initiated by the Australians into their mysteries, which they describe as being of an obscene nature, whenever they make themselves known to the natives by secret signs they have learned, are implored not to divulge the sacred mysteries.

The same freemasonry exists among the natives of America and of Central Africa. Among the latter, the priest is called an *Obi* man, and the temples where these secret rites are observed are called *Oboni*, or houses of *Obi*, and are ornamented with phallic emblems, or symbols of generation.

Now, I have found that *Obi* means, in Central Africa, *an ancestor*, one who begets. Hence the Obi man is inspired by ancestors, and the Oboni are temples of the dead. Our very word necromancy (prophecying by aid of the dead) carries us back to the Obi of the Africans. At the Oracle of Delphi, the priestess, before she uttered responses, was inspired by Ob, and must have been originally nothing more or less than an Obi woman.

Is it not strange that phallic emblems, though so offensively significant, have been assigned by the learned to almost everything except to the worship of ancestors?—See Report on Aborigines, p. 64, 69, 70.—See Bowen's

Such then, north of the equator, are the scattered fragments of, what we can only regard as the wreck of the primitive Southern year, and of its new year's festival of first fruits, and the dead. I have endeavoured to collect together these *disjecta membra*, diffused and hitherto lost in vague myths, confused calendars, uncertain traditions, and obsolete customs.[46] Yet, in the New, as well as in the Old World, civilized and savage races gaze with equal wonder on the memorials, that everywhere exist, of the observance of this festival by primeval man. In the large deposits of ashes, and of the remains of food, found in vast burial tumuli in Australia, America, and Asia, the graves of races long extinct,[47]

Central Africa (New York, 1857), p. 271, 315 to 319; also Dictionary of Yoruba Language, Smithsonian Contributions, x. xvi., xix. 109—De Rougemont's Peuple Primitif, ii. 363. I refer those who may take an interest in such matters to the following authorities as to the funereal character of ancient mysteries, and the time of their observance, etc.: Dupuis, i. 234 and seq., 312, 340, 349, 364, 390, 402, 410, 422, 427, 439, 443. Boulanger L'antiquite devoilee, i., p. 269 to 303; iii. 178 to 186. St. Croix sur les Mysteries du Paganisme, i. 54, 55, 66, 75, 78, 317, 340, et passim. Le Monde primitif, iii. 329. Ouvaroff on the Mysteries, p. 1, 27; also Christie's notes, 169, 172. Warburton's Divine Legation of Moses, Faber's Origin of Pagan Idolatry, and Bryant's Mythology are principally devoted to a subject which has caused more learned and fruitless speculation than any other topic connected with the history of ancient nations.

[46] Though it has required much time and labor to collect even the materials which I have used respecting this festival north of the equator, the difficulty has been far greater in obtaining any definite information regarding its observance in the southern hemisphere; first, because travellers are generally ignorant of, or inattentive to, the festivals of savage races, and rarely specify the time or the particulars of their observance; and secondly, because in a colony, from the absence of extensive libraries, it is almost impossible to glean precise information, which, even if it exists, can only be procured from a large number of writers. As regards Polynesia, I have felt this difficulty very much. Ellis, on whom I have had mainly to rely, though he regards the Polynesians as belonging to the same race, and almost identical in their customs and religious ideas, does not clear up a point of no little importance in these investigations, as to the festival of the dead, and the year of the Pleiades existing universally throughout the Pacific Islands, his remarks being, in a great measure, confined to the groups of numerous islands known as the Georgian and Society Islands. Even his work I could not procure while writing this paper. I had therefore to rely on notes made some years ago, while reading his works, before my attention had been particularly drawn to this subject. As, however, south of the equator, on the west coast of South America, among the ancient Peruvians, as well as in the Southern Pacific, in Tahiti, the Tonga Islands, and Australia, we find the year of the Pleiades, or its new year's festival, there can be but little doubt that equally distinct traces of them will be found in the more northern islands of the Pacific. A reference to Crawford's "Indian Archipelago" will confirm this view. See i. 28

[47] See Report on Aborigines, p. 62. The work of Messrs. Squier and Davis on the Mississippi mounds, and Dr. McPherson's researches at Kertch throw a light on this subject.

we have significant evidence of this new year's commemoration dating back to the most remote ages; while even at the burial cave at Aurignac, to which an antiquity of not less than 8000 years is assigned by some authorities, we have the same memorials of the feasts and fires of this ancient festival.[48] Its memory has long been forgotten. Preserved only in the rites of heathen races, or merely lingering, among civilized nations, in the customs and superstitions of the peasantry, this festival has never been considered worthy of the attention of the historian or of the ethnologist; and this paper is the first attempt that has been made to throw any light on its history or its origin.

I have restricted my remarks to such points as connect it with a year commencing in November, a branch in itself far too extensive for the space at my disposal. My next paper will show the light which this festival, occurring in February, throws on the primitive northern year; and my third will be devoted to a far more interesting and easier branch of inquiry, as to the prime origin of this festival of the dead, and the influence it has exerted on the idolatry, the mythology, and the religious rites of all ancient nations,—an influence even still discernible in the customs and modes of thought of civilized nations.

That, from Australia to Britain, we have all inherited this primitive year and its new year's festival, from a common source, is plainly manifest. Was it carried south by north nations; or, has there been a migration of southern races to northern latitudes?

[48] The existence of articles resembling American wampum in the cave at Aurignac is peculiarly interesting, both as tending to throw light on the habits of the race that then existed in Europe, and as giving some clue to their representatives among existing nations. The cowrie (Cyprea moneta) is used in Asia and Africa, and is entirely different from the relics to which I refer. In America, shell money is made from the shell of the hard-shelled clam (mercenaria violacea, Schum), which is cut into small oblong pieces perforated for the purpose of being strung into *"belts* of wampum," which are buried with the possessor at his death. Hence in most Indian graves we find numerous pieces of perforated shell. This throws a light on the following passage in Sir Charles Lyell's "Antiquity of Man" (p. 188): "Mixed with the human bones, inside the grotto, first removed by Bonnemaison, were eighteen small, round and flat plates of a white, shelly substance, made of some species of cockle (cardium), and pierced through the middle, as if for being strung into a bracelet."

As there is no further remark concerning these specimens resembling wampum, soon after the work appeared, I drew the author's attention to the point. They are plainly not cowries, as the shape precludes such an inference.

Should the use of wampum be limited to the New World, an inquiry into this subject may lead to interesting conclusions. The mode of making wampum is described in a note to "Rule and Misrule of the English in America," by the author of Sam Slick, b. ii., ch. v. See Prehistoric Man, by Dr. Danl. Wilson, i. 218, 443; ii. 147.

That the "Feast of Ancestors," which still lingers in our All Halloween, All Saints, and All Souls, is the same as the *Inachi* of the south, and was originally the new year's festival of a primitive year commencing in November, is a matter, which can, I believe, be established beyond any question; but in what part of the world it first originated, is necessarily, with me, a matter of vague conjecture only, especially with the limited materials I possess respecting the festivals of southern races. The fact, that the year of the Pleiades, as well as the ancient reverence for that constellation, only now exists south of the equator, is, however in itself very significant. We have hitherto examined the universal customs of nations, let us now turn to those widespread primitive traditions, which though hitherto unexplained, and apparently inconsistent with each other, have been regarded from the days of Plato to the present as embodying the dim outlines of primeval history.

First—We have the very remarkable tradition of remote antiquity, referred to by Plato, and by modern writers, as to the sun, moon and stars having once risen in the opposite quarter to what they now do. Greswell[49] regards the tradition as historical evidence of a miracle. Can it be explained by natural causes? It can; but only in one way—by supposing a migration of races from south to north of the equator.

To the Tahitians, the sun, moon and stars rise on their right hand; to us they rise on the left.

Second—The most ancient tradition perhaps in the world, one that has left its impress on the astronomical systems, in the religious rites, and even the social customs of nations from Syria to Japan preserves the belief of the Chaldæans that the first inhabitants of Asia were a maritime race that landed on the shores of the Persian Gulf.[50]

Third—From China to ancient Britain prevailed the uniform belief that the ancestors of the human race came from Islands; and from the time of Plato to the present, scores of volumes have been written on the subject.[51] A celebrated French philosopher asks us, "Ne trouvez vous pas, Monsieur, quelque chose de singulier, dans cet amour des anciens pour les isles? Tout ce qu'il y a de sacré, de grand,et d'antique, s'y est passé: pourquoi les habitans du continent ont ils donné cet avantage aux isles, sur le continent même"?[52] An enthusiastic Welshman has gone near home for the primeval paradise, though a mistaken impression undoubtedly

[49] Fasti Catholici, i. 343.
[50] Faber's, ii. 378. De Rougemont, i. 325; Dupuis, i.; Layard's Nineveh and its Remains, ii. 466.
[51] De Rougement, ii. 248. Faber's Origin of Pagan Idolatry, i. 393.
[52] Letters sur L'Atlantide, par M. Bailly, p. 361.

existed among ancient nations, that Britain much more nearly resembled the infernal regions.[53]

Let us imagine that a migration did take place from southern latitudes, and what would be the result? The wanderers would bear with them a recollection of the islands of the south, which they had left. They would see with dread and remember long, that the stars that once rose on their right hand, had apparently reversed their movements. They might bring with them a year of seasons only suited to their former homes.

The stars that once announced spring would long continue to be reverenced as the Vergilliæ, though rising at the beginning of summer. Once marking the commencement of the year by appearing to their worshippers on the southern Halloween, and hence causing "the evening and the morning" to be "the first day," the Pleiades would long retain their name as the Hesperides (the stars of the evening), even when they had ceased to regulate the year, when their "pleasant influences" had been forgotten; when their rising in the evening was no longer reverenced, and their heliacal rising and setting in the morning was alone regarded;[54] when even that mode of regulating the seasons had been disused, and the past influence and history of the Pleiades only existed as a matter of fable and of doubt even to astronomers themselves. Yet we find among ancient nations, that the Hesperides were connected most singularly with the traditions as to the primitive abodes of our race. The Southern Garden of the Hesperides recalls them to our mind;[55] while the name of these daughters of Atlas and of the Ocean, is blended with the memory of the lost Island of Atlantis. The key to many a mysterious myth will yet be found in the history of the seasons of the Pleiades.[56]

[53] Davies' Mythology of the British Druids, 158, 181.

[54] See Greswell's Orig. Kal. Ital., iii. 58, 469, 516. Also Fasti Catholici, ii. 110, which is particularly in point; also 104. Dupuis, ix. 185. See Cornewall Lewis' Astronomy of the Ancients, p. 11, 25, 60 to 67.

[55] See Dupuis, i. 329. De Rougemont, ii. 248.

[56] As the fables of Io and Icarus, hitherto unexplained, seem to relate to traditions as to a migration of races, and to changes in the seasons, it may be worth while to refer to them here. Io, the daughter of *Inachus*, is the same as Isis, who, we have seen, is plainly a mythical embodiment of the primitive year, and of its funereal and agricultural New Year's festival. The name of the Hindoo Isis, Cali, means *time*. Mythology tells us that Io, accompanied by the Pleiades, after wandering over the whole earth, and being persecuted by Juno, on account of Jupiter, arrived at last at the Nile, where she was worshipped as Isis. To what can this refer, except to a year regulated by the Pleiades, having been brought from some distant country, and embodied in the myth of Isis. The fable of Io appears plainly in the Hindoo god, *Carticeya* (the Pleiades?). A reference to the

To be Continued

MEETINGS OF THE SOCIETY

At Toronto.

January 27, 1920.—The annual "At Home" was held in the Physics Building of the University of Toronto on Tuesday evening, January 27th, 1920. The president-elect, Mr. J. R. Collins, in the chair.

There was a very large attendance of the members and their friends. The chairman welcomed the audience, especially those who were not members of the society, and read the list of officers for the coming year.

The retiring president, Mr. A. F. Miller, delivered an address on "Some Astronomical Results during 1919". The address was published in the last number of the JOURNAL.

Mr. J. A. Paterson, K.C., in moving a vote of thanks to the lecturer, stated that Mr. Miller was not only an able administrator but also a competent experimenter and practical astronomer.

Dr. C. A. Chant explained the various exhibits mentioned in the program, and a pleasant hour was spent in examining them. Light refreshments concluded a very enjoyable evening.

February 10.—The Society met at 8 p.m. in the Physics Building of the University, the president, Mr. J. R. Collins, in the chair.

Mr. Peter L. Trout, of Toronto, gave the address of the evening on "The Moon and Planetary Evolution".

During the course of his interesting paper Mr Trout expressed several original ideas. He attributed the silvery whiteness of the moon to the solidified air on its surface, and thought the so-called polar caps of Mars due to the same cause. The moon resulted from a tremendous catastrophe when a portion of the crust of the earth was cast into space to form the moon. The earth was thrown out of balance, but its equilibrium was quickly restored because 95% of the earth was liquid. The remainder of the crust floated upon this liquid. North and South America broke away from Europe and Africa, and floated across to their present positions. The British Isles broke away from the mainland. A new crust was formed, and wherever we have the old and new crusts meeting, mountains occur. This explains the presence of the mountains along the Pacific. The atmosphere of Mars offers little protection from the coldness of space so that we have to conclude that all animal and vegetable life has long ago become extinct. There is some evidence, however, to show that Venus is much in the same stage as the earth was in during the Tertiary Period.

An interesting discussion followed the lecture, in which several of the members expressed their opinions.

February 24.—The Society met in the Physics Building of the University at 8 p.m., the vice-president, Mr. W. E. W. Jackson, in the chair.

The following were elected members of the Society:

Mr. M. R. de Meslé, of Montreal; Mr. A. C. Rhea, Thorp, Wis.; Rev. J. T. Brennan, Espanola, Ont.; Mr. E. T. Scott, Winnipeg, Man., and Rev. Joseph Saguista, Tortosa, Spain.

Mr. A. F. Hunter reported that he had observed no less than 12 halos during the past two months. The halo of January 14th was singular in that the upper tangent was brilliant and persisted for two hours; the worst storm of the season occurred on the following day. Mr. W. E. W. Jackson observed the same halo. He stated that sun spots during January and February were numerous but small.

Dr. C. A. Chant gave the paper of the evening on Mars, illustrating his lecture by many slides. Mars has been much in the eye of the public of late on account of the statements of Marconi, that he has received strange signals on his wireless aparatus, possibly coming from the planet. By means of models and slides the circumstances of the coming opposition of the planet were explained. The lecturer next explained the general production and propagation of wireless waves. Assuming that 10 kilowatts of energy is required to signal 3,000 miles, it was estimated that it would require 324×10^7 kilowatts of energy to send wireless waves to Mars, even if they could penetrate the Heaviside layer of the upper atmosphere; so that we certainly could not send wireless waves by any means we have at present.

The method of signalling by means of light was also discussed, the conclusion being reached that the amount of energy necessary to signal was far in excess of the energy at present available. Moreover, when Mars is in opposition, and therefore nearest us, we are invisible to people on Mars (if they exist), so that they could not see our signal. Thus by either means at present communication to Mars seems little more than a dream.

March 2.—The Society met in the Physics Building of the University at 8 p.m., the vice-president, Mr. W. E. W. Jackson, in the chair.

Professor C. A. Chant delivered the second of his series of three lectures, the subject for this evening being "Celestial Visitors". The lecturer explained the various terms defining the orbit of a comet, and gave an example of how a comet is found and reported to the distributing centres, the Harvard Observatory being the centre for this continent, and the Royal Observatory, Brussels, the centre for Europe. These stations telegraph the position of the new comet to all observatories.

In August of last year the Rev. Joel Metcalf, of Winchester, Mass., established a record by finding three comets within forty-eight hours, one of which had been previously reported, though it was unknown to him.

The relation of meteors to comets was then explained.

H. A. Newdon was able to trace the history of the Leonids as far back as 900 A.D. They have a period of thirty-three years, and Schiaparelli proved in 1866 that they follow in the path of the comet of 1863 (2). Similarly the Perseids have an orbit identical with that of the great comet 1862 (1), the period of which is 120 years. Biela's comet, period 6 years, strangely disappeared and in its place appeared the Andromedes, which are regarded as the remnants of the comet.

Of all the meteorites found in Ontario, only two are on record as having been actually observed to fall. Of these the Shelburne meteorite of 1904 is the most celebrated. This meteorite was described in detail and models of it exhibited.

March 9.—The Society met in the Physics Building of the University at 8.00 p.m., the vice-president, Mr. W. E. W. Jackson, in the chair.

The following were elected members of the Society:

Alexander B. McKay, M.A., LL.D., Calgary, Alta.; Charles C. Conroy, Los Angeles, Cal.; W. F. W. Lent, Calgary, Alta.: J. H. Horning, B.A., Toronto, Ont.

Professor C. A. Chant gave the third lecture of his series, his subject being, "Great Telescopes and Their Importance in Future Discovery". Illustrating the lecture with many slides, he first traced the development of the 72-inch Reflecting Telescope, now installed in the Dominion Astrophysical Observatory at Victoria, B.C.

The giant mirror, weighing nearly 5,000 pounds, was successfully cast at the works in Charleroi, Belgium. It left Antwerp just one week before war was declared. The grinding and polishing was done by the Brashear Co. of Pittsburg, the mirror being pronounced perfect to the one four hundred thousandth of an inch in March, 1918, after nearly three and a half years of work. The finished mirror measured 72 inches in diameter, 12 inches thick, and weighed 4,340 pounds.

The construction of the observatory, telescope and dome were described in detail. The observatory had been completed in October, 1916, and it was only one week after the mirror arrived until it was installed, collimated, and the first spectrum of the stars obtained. This is a record performance for such a large telescope.

The telescope is primarily intended to be used for spectroscopic work, but many of the heavenly objects have been photographed. Slides showing the great nebulae of Orion and Andromeda, the Ring Nebula of Lyra, the wonderful star Cluster in Hercules, and parts of the Milky way were exhibited.

The lecturer next explained the construction and use of the 150 foot Tower Telescope on Mount Wilson, Cal. This telescope is used essentially to study the sun, and since its installation much important work has been done. The spectrum of the sun is so dispersed as to cover a length of 40 feet; thus any region may be sutdied in great detail.

The third telescope described was the one hundred inch reflecting telescope on Mount Wilson, the largest telescope yet constructed. Among the pictures

shown, which were taken by this instrument, were three magnificent ones of parts of the moon, exhibiting the lunar features in minute detail.

March 25.—The Society, members of the University and their friends, met in the Physics Building at 8.15 p.m., Brig.-Gen. C. H. Mitchell, Dean of the Faculty of Applied Science, in the chair.

The guest of the Society was Professor E. E. Barnard, of the Yerkes Observatory, Chicago. The Chairman, in presenting the distinguished astronomer, referred briefly to his great reputation, he having done more than any other person in the development and application of photography to astronomy.

Professor Barnard introduced his lecture on "Photographic Revelations in Astronomy" by stating that the great value of photography in astronomy lies in its power to correctly portray the heavenly bodies, its fide ity in recording their minutest details and slightest changes. Such changes are of profound interest to astronomers, as many discoveries have been based upon them. The artist, however skilful he may be, fails when he attempts to picture the sky, because his eye, hand and mind are fallible, but the photographic plate, being the more sensitive the longer the exposure, sees what the eye cannot see.

Pictures of some of the observatories on this continent and their instruments were exhibited. The lecturer explained that the advantage of the great reflecting telescopes at Mount Wilson and Victoria, where Dr. Plaskett is doing such splendid work (applause), is in their power of collecting the light so that photographs are obtained by a few minutes' exposure, whereas the same photos taken by a refractor would require several hours' exposure.

Pictures of every type of celestial objects were shown and explained. Particular mention must be made of the views of the Moon, Mars and Saturn, the series of coloured plates showing various phases of a singularly fine prominence, the wonderful Clusters Messiers 8, 13, and 21, the rich regions of the Milky Way, the Pleiades enshrouded in vast banks of nebulosity, the planetary and spiral nebulae, those island universes whose details are gradually being revealed by the searching eye of the camera. "These, and many other wonders you will have the pleasure of seeing with your own eyes when you get your new observatory". (Prolonged applause.)

Professor Chant, in moving a vote of thanks, remarked that never in Toronto had a larger or more representative audience gathered to listen to an astronomical lecture, for which he ascribed two reasons, firstly, to greet the celebrated lecturer, and secondly to hear of the proposal of the new observatory. He then briefly outlined the proposition. Mr. A. F. Miller seconded the vote of thanks which, having been presented and replied to by Professor Barnard, concluded the meeting.

J. A. PEARCE, *Recorder.*

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada
January, 1920

Temperature

The mean temperature was below the normal throughout the Dominion, except in the extreme Southern districts of British Columbia and Alberta where the normal was just maintained. The negative departures ranged between 3° and 6° over the greater part of the Prairie Provinces, while from the Great Lakes to the Atlantic, where the departures were from 7° to 12°, it was one of the coldest Januarys on record.

Precipitation

The precipitation was above the normal over the greater portion of British Columbia and the Western Provinces, while from the Great Lakes eastward, except in a few localities in Ontario, it was considerably less than normal. Throughout the Prairie Provinces and in Ontario, Quebec and New Brunswick the precipitation was entirely in the form of snow. Rain occurred on several days near the British Columbia Coast and on some three or four days in Nova Scotia, but the amount in the latter Province was quite light, and of the total precipitation a large proportion was in the form of snow.

TEMPERATURES FOR MONTH OF JANUARY, 1920

STATIONS	JANUARY		STATIONS	JANUARY	
	Highest	Lowest		Highest	Lowest
Yukon			Huntsville	—	—
Dawson	8	−58	Kenora	22	−36
British Columbia			Kinmount	—	—
Atlin	—	—	Kingston	36	−22
Agassiz	52	18	Kitchener	33	−19
Barkerville	39	−26	London	34	−16
Kamloops	51	− 9	Lucknow	32	−22
New Westminster	51	19	Markdale	34	−24
Prince Rupert	50	7	North Gower	—	—
Vancouver	50	17	Oshawa	—	—
Victoria	53	25	Ottawa	35	−29
Western Provinces			Paris	35	−21
Battleford	35	−43	Parry Sound	36	−28
Calgary	48	−34	Peterborough	34	−28
Edmonton	44	−46	Port Arthur	30	−27
Medicine Hat	46	−40	Port Burwell	34	−20
Minnedosa	30	−42	Port Dover	35	−15
Moosejaw	36	−39	Port Stanley	35	−14
Oakbank	27	−42	Queensborough	34	−35
Portage la Prairie	—	—	Ronville	32	−36
Prince albert	35	−44	*Ontario—continued*		
Qu'Appelle	34	−41	Southampton	34	−19
Regina	32	−45	Stonecliffe	32	−36
Saskatoon	33	−41	Stoney Creek	37	−17
Souris	31	−38	Toronto	37	−18
Swift Current	45	−38	Uxbridge	32	−32
Winnipeg	26	−38	Wallaceburg	35	—
Ontario			Welland	36	−10
Agincourt	35	−21	White River	28	−48
Aurora (Oak Ridges)	33	−24	*Quebec*		
Bancroft	32	−37	Brome	47	−26
Barrie	33	−26	Father Point	30	−24
Beatrice	33	−30	Montreal	34	−23
Bloomfield	35	−25	Quebec	32	−28
Brantford	39	−16	Sherbrooke	36	−30
Chapleau	16	−48	*Maritime Provinces*		
Chatham	35	−10	Charlottetown	34	−16
Clinton	33	−23	Chatham	34	−24
Collingwood	40	−25	Dalhousie	—	—
Cottam	32	− 9	Fredericton	36	−24
Georgetown	35	−21	Halifax	36	−16
Goderich	—	—	Moncton	36	−22
Gravenhurst	35	−34	St. John	36	−20
Grimsby	35	− 9	Sussex	35	−25
Guelph	32	−20	Sydney	36	−14
Haliburton	33	−35	Yarmouth	40	− 4

EARTHQUAKE RECORDS BY MILNE SEISMOGRAPH, TORONTO

SIR FREDERIC STUPART, F.R.S.C., DIRECTOR

No.	Date 1920	P. T. Comm.	S. Comm.	L. W. Comm.	Max.	End	Max. Amp.	Remarks
		h m	h m	h m	h m	h m	mm.	
	Jan. 1	st.—Sma	ll micros m	asked any	quake a	t 2.42a s	record	ed at other station.
2084	Jan. 1			13 01.8)	13 10.5	Micros	0.3	Micros masked ini-
				13 06.4)				tial phases.
2085	" 1			16 37.3	16 40.6	Micros	0,2	Gradual thickening. Well marked
	" 2	Micros	masked she	et when ot	her stat	ion reco	rds qu	ake.
2086	" 4	4 27.6)	4 33.0	4 41.9)	4 47.8	5 23.6	1.0	3610 Km. Disas-
		4 28.8)		4 43.4)				trous Mexican quake.
2087	" 12			14 16.7)			0.1	
				14 22.7)				
2088	" 12			14 39.1)	14 46.5		0.2	May not be seismic.
				14 44.2)				
2089	" 13	23?27.5		23 54.0)	0 13.5	0 54?5	0.3	
				0 00.1)				
2090	" 14			1 02.1)	1 19.8	1?22.6	0.2	May not be seismic.
				1 18.6)				
2091	" 14	15 41.8		15 49.2)	15 54.7	16 51.6	0.8	
				15 50.5)				
2092	" 14			17 33.3			0.1	
2093	" 15			12 37.6	12 49.7		0.2	
2094	" 20			17 00.4	17 01.8	17 17.6	0.2	May not be seismic.
2095	" 22			22 25.1	22 30.2	22 45.0	0.3	
2096	" 22			23 58.3	3 59.3	0 06.4	0.2	
2097	" 24			7 17.9)			0.1	May not be seismic.
				7 37.9)				
2098	" 30	18?37.0	18 43.3	18 47.5	18 49.9		1.3	Small miscros inter-
								fere with P waves.
2099	" 30			20 29.3)			0.2	Micros going on.
				20 32.2)				

Period of Boom 18 seconds. Pillar inclination 1 m m =0″.45.

EARTHQUAKE RECORDS BY MILNE SEISMOGRAPH, VICTORIA, B.C.

F. NAPIER DENISON, SUPERINTENDENT

No.	Date 1920	P. T. Comm.	S. Comm.	L. W. Comm.	Max. Max.	End	Max. Amp.	Remarks
		h m s	h m s	h m s	h m s	h m s	mm.	
2076	Jan. 1	2 42 06			2 46 02	2 49 58	0.1	
2077	" 1			12 46 04	12 50 59	13 21 29	0.1	
2078	" 2	13 20 35		13 22 04	13 22 33	13 30 25	0.5	665 Km. May be off West Coast.
2079	" 4	4?30 29	4 34 25	4 40 49	4 47 42	5 33 56	1.6	239 Km? Destructive quake in Mexico.
2080	" 7				9 44 56	9 50 53	0.2	
2081	" 12	14 00 50	14 06 15	14 12 38	14 18 32	14 53 56	0.4	3620 km. Mexico?
2082	" 13	23 23 32		23 40 15	23 45 45	1 45 10	0.7	
2083	" 14	15 02 25	15 08 19	15 19 08	15 27 29	17 03 53	0.4	4120 km. Mexico?
2084	" 15			12 28 04	12 32 29	12 39 52	0.1	
2085	" 21			6 30 47		6 42 41	0.05	
2086	" 22	21 42 00	21 48 06	21 55 46	22 03 22	22 43 29	0.5	4330 km. Prob. Mexico?
2087	" 24	7 09 16			7 09 20	7 24 01	2.0	35 km. Felt in Victoria and generally through- out Vancouver. Prob. under Strait of Georgia and NE of Victoria.
2088	" 30	18 44 23	18 49 48	18 54 42	19 12 30	19 24 00	0.5	3620 km.
2089	" 30				20 13 01	20 24 25	0.4	

Period of Boom 18 seconds. Pillar inclination 1 m m =0″.54.

VERTICAL SEISMOGRAPH.

	" 2	13 20 10		13 21 20	13 23 00	?	4	520 km. L may be S phase.
	" 4	4 29 25	4 34 20	4 43 30	4 47 46		4	3170 km. Mexico.
	" 24	7 09 16		7 09 18	7 09 20	7?12 30	214	35 km.

REPORT ON EARTHQUAKE FELT AND RECORDED AT VICTORIA ON JANUARY 24TH, 1920, G.M.T.

At 7 hours, 9 minutes and 16 seconds, Victoria experienced a local earthquake of considerable intensity, and from the seismograph records obtained here both on the E-W horizontal pendulum and the vertical instruments, the centre of the disturbance does not appear to have been more than 20 miles distant. The East-West seismograph indicated a sudden and pronounced movement, while the vertical instrument sustained a sudden jar sufficient to permanently displace the recording needle by .007 mm. and raised the needle off the paper for the first few seconds. The amplitude of the maximum wave, which occurred four seconds after the first wave, was .214 mm., and the time interval two seconds.

The number of seconds that the quake was felt varied considerably according to location and nature of foundation. Here on the rock and in this concrete building the quake was felt for about five seconds and consisted of two maximum vibrations, the latter being the most pronounced.

Pictures on the wall moved slightly, though no abnormal movement could be detected on the recording pen of the barograph. In some sections of the city household articles were moved and considerable alarm prevailed, though no damage has been reported.

From reports received from other districts it would appear that the disturbance originated under the Strait of Georgia and to the north-east of Victoria. At Bellingham, Wash., a number of brick walls were cracked. At Anacortes, Wash., windows in some houses were broken and brick walls cracked.

At Vancouver the quake was first felt at 7.9.35 sec. or 19 seconds after the quake was recorded here. It was quite severe in certain districts and particularly at the tops of high buildings.

At Brentwood, on the Saanich Arm, about 14 miles from Victoria, the concrete chimney and wall of the electric power station was cracked. At Ladysmith our observer reported a distinct quake commencing 11.10.30 (Pac. Time), the first shock lasted about seven seconds, followed in about a second by another lasting about the same time. The buildings shook and the windows rattled considerably. At Nanaimo our observer reports a quake at 11.10 p.m. (Pac. Time) which caused the substantial stone buildings to shake and the windows to rattle. At Port Alberni, Mr. Allard, of the E. & N. Ry. staff, reported a quake at 11.15 p.m. (Pac. Time) lasting about four or five seconds; the intensity was mild compared with that of 1919, and nothing appeared to rock.

The feeling of the D.G.S. "Estevan", which was anchored near Active Pass at the time of the quake, was as if she was striking the rocks due to the seismic waves passing through the water.

At the light-house nearby the metal chimney was badly damaged. I am inclined to think the maximum surface movement was in the vicinity of Mayne Island.

The S.S. "Quadra", which was also in this area at the time of the quake, experienced several severe blows as if she had struck floating logs.

From a close inspection of the Victoria Tide Gauge record there did not appear to be any abnormal movement at the time of the quake.

F. Napier Denison,
Meteorological Observatory, Gonzales Heights, Victoria, B.C.

Magnetic Observations

In accordance with the statement made in the April, 1919, number of The Journal the monthly values of the Magnetic elements for Agincourt and Meanook have not been published, pending the final analysis of the data obtained during the calendar year. The analysis for 1919 has now been completed and the accompanying tables give the results by months for D, H and Z at Agincourt and of D at Meanook derived from the photographic records. The value of I at Agincourt is obtained from the values for H and Z.

The values of H and I at Meanook are obtained from absolute observations, uncorrected for diurnal variation, made twice a month for H, and weekly for I. The value of Z is determined from those for H and I. All observations have been corrected to International Magnetic Standard.

RESULTS OF MEGNETIC OBSERVATIONS AT AGINCOURT FOR 1919

Lat. 43 47′ N; Long, 79 16′ W

West Declination

	Mean of Month	Maximum	Date of Max.	Minimum	Date of Min.	Monthly Range	Mean Daily Range	
							From 24 hour readings	From means of extremes
	° ′	° ′		° ′		° ′	′	′
January	6 39.0	7 27.9	14	5 52 5	4	1 35.4	10.6	25.5
February	39.6	7 11.9	27	6 06.9	28	1 05.0	7.6	23.0
March	40.2	7 15 7	22	5 46.7	20	1 29.0	9.9	31.7
April	40.4	7 07 8	8	5 55.2	6	1 12.6	13.6	25.7
May	40.2	7 54.8	3	5 32.9	2	2 21.9	11.5	32.9
June	39.9	6 59.1	22	6 12.0	9	0 47.1	15.6	21.2
July	40.2	7 00.5	18	6 10.6	22	0 49.9	14.9	20.6
August	41.8	8 45.0	11	5 01.3	11	3 43.7	17.1	31.7
September	42.2	7 34.0	19	5 56.2	19	1 37.8	13.5	29.9
October	42.5	8 17.1	5	5 50.1	1	2 27.0	10.1	37.7
November	42.5	7 07.9	4	6 15.6	16	0 52.3	6.8	15.2
December	42 9	7 35.5	15	6 08.4	15	1 27.1	6.2	16.5

HORIZONTAL FORCE

	γ	γ		γ		γ	γ	γ
January	15896	16001	4	15666	14	335	36	83
February	894	158	27	717	28	441	37	94
March	884	238	20	608	21	630	57	129
April	894	041	17	537	7	504	52	106
May	891	170	2	386	3	784	66	153
June	903	001	25	832	12	169	54	81
July	897	018	1	680	22	338	48	82
August	873	248	11	318	11	930	66	128
September	866	122	19	607	20	515	51	108
October	863	346	1	464	3	882	48	151
November	878	15922	16	772	4	150	25	47
December	878	15916	14	494	15	422	22	62

RESULTS OF MAGNETIC OBSERVATIONS AT AGINCOURT FOR 1919
LAT. 43 47′ N; LONG. 79 16′ W
VERTICAL FORCE

	Mean of Month	Maximum	Date of Max.	Minimum	Date of Min.	Monthly Range	Mean Daily Range	
							From 24 hour readings	From means of extremes
	γ	γ		γ		γ	γ	γ
January	58317	58426	4	58143	14	283	16	38
February	313	389	27	58117	28	272	17	41
March	300	604	20	58167	28	437	35	76
April	281	443	17	58062	17	381	29	68
May	273	486	2	57946	3	540	57	126
June	250	330	9	58160	25	170	19	57
July	240	331	22	57978	22	353	19	51
August	234	697	11	57718	11	979	34	92
September	228	551	6	58077	20	474	39	90
October	233	461	4	57844	3	617	38	112
November	221	277	16	58154	12	123	9	39
December	224	291	3	57904	15	387	19	36

RESULTS OF MAGNETIC OBSERVATIONS AT MEANOOK FOR 1919
LAT. 54 37′ N; LONG. 113 21′ W
DECLINATION EAST

	Mean of Month	Maximum	Date of Max.	Miminum	Date of Min.	Monthly Range	Mean Daily Range From 24	Mean Daily Range From
							hour readings	means of extremes
	° ′	° ′		° ′		° ′	′	′
January	27 42.4	29 28.4	4	26 21.7	31	3 06.7	9.4	43.7
February	42.4	29 20.0	23	26 26.4	1	2 53.6	9.3	50.8
March	42.9	29 37.0	22	26 43.1	16	2 53.9	11.5	59.3
April	41.3	29 31.1	7	26 03.2	7	3 27.9	14.4	57.6
May	41.0	29 30.1	3	26 20.6	2	3 09.5	19.9	61.5
June	39.2	28 07.4	9	26 31.7	11	1 35.7	18.5	31.2
July	39.5	28 53.7	17	26 33.5	22	2 20.2	18.0	35.1
August	40.6	29 37.7	11	25 40.8	11	3 56.9	21.7	49.4
September	41.0	29 43.4	19	26 12.1	19	3 31.3	16.5	50.2
October	41.1	29 37.1	26	25 41.3	27	3 34.9	10.7	72.5
November	40.8	29 17.2	4	26 59.0	22	2 18.2	6.3	28.8
December	40.5	30 01.4	15	26 10.0	15	3 51.4	8.8	32.9

RESULTS OF MAGNETIC OBSERVATIONS AT AGINCOURT AND MEANOOK FOR 1919

	Ag. I	Me. I	Me. H	Me. Z
	° ′	° ′	γ	γ
January	74 45.2	77 54.2	—	—
February	45.2	54.5	12936	60384
March	45.6	54.8	36	410
April	44.7	54.2	48	414
May	44.8	53.5	46	345
June	43.8	53.4	48	346
July	43.9	54.2	59	466
August	45.2	54.9	46	465
September	45.5	54.3	56	460
October	45.7	54.5	54	468
November	44.7	54.6	31	369
December	44.7	53.8	29	287

ASTRONOMICAL NOTES

ERATOSTHENES I, A STUDY FOR THE AMATEUR

Eratosthenes can readily be found by anyone who has even a slight knowledge of the lunar surface, since it lies 10° to the northwest of Copernicus, and on a small scale closely resembles that crater when the Sun first rises upon it. As the lunation progresses, however, Copernicus turns white, from the precipitated cloud and snow, while Eratosthenes turns dark, from the growth of the vegetation within and around it. Very soon they are quite unlike, and at full moon, while Copernicus is conspicuous, Eratosthenes can only be found by one who has carefully watched and drawn it night after night, and who knows just where to look for it. For three days at this time it is difficult to recognize, but after that it reappears, and remains conspicuous for the remainder of the lunation. Since it is situated in latitude 14° N, it is located near the centre of the disk, and there is no trouble from libration It is 37 miles (59 km.) in diameter, and its walls rise to an elevation of nearly three miles above the interior.

Photographs show that large areas of vegetation surround the crater, particularly on the west and north, these areas being nearly invisible in the photographs, taken soon after sunrise on the Moon. If the lunar vegetation has leaves, we must consider that only the twigs and branches are visible near sunrise and sunset. Its form is of course quite unknown to us and the phenomena may consist merely in the darkening and fading of its exposed surface. As has been mentioned in previous articles, we assume the phenomena to be due to vegetation, because that explanation is plausible, and because none other of any sort has ever been offered for it. That clouds and snow occur upon the Moon, and that consequently it possesses at least a slight atmosphere has been shown in the papers on Meteorology of the Moon (*Popular Astronomy*, 1915, 23, 129), The Snow Peaks of Theophilus (*Popular Astronomy*, 1917, 25, 149), and elsewhere. There is therefore no reason why vegetation should not exist.

The lunar vegetation is not green. It is gray like our sage brush and some of our cacti, and black like our lichens,—almost a purplish black in some places, near the equator. The vegetation on Mars we know is also gray for most of the year. The lunar vegetation is scattered, generally in rather small patches over the surface. None is found near the poles. The only greenish spot located upon the Moon is the floor of the great crater Grimaldi, but even here the colour is not marked. By far the greater part of the lunar surface appears to us to be simply a desert waste. The vegetation, where found, is often associated with minute craterlets, as in Alphonsus, the craterlet occurring at or near the centre of he

dark area. Sometimes it is associated with rills as in Atlas. In any case its growth and decline must necessarily be very rapid, the changes being most marked near the time of the crater's summer solstice. Consequently they always occur at a considerable distance from the terminator, or in a portion of the Moon which the amateur seldom examines with care. Near the terminator, on the other hand, few changes of interest occur other than the shifting shadows, which can hardly interest the professional selenographer.—W. H. PICKERING in *Popular Astronomy*, Nov. 1919.

EINSTEIN'S RELATIVITY THEORY.

Einstein's statement ,"If any deduction from it [the theory] should prove untenable, it must be given up", is of special interest. Just above this statement he gives the only three cases yet suggested in which the theory can be subjected to test by actual observation. Let us consider these briefly.

1. The only planet orbit really available for this test is that of *Mercury*. Grant that the theory here offers an explanation of the observed acceleration of the perihelion; it is also true that there may be an alternative explanation under the Newtonian law of gravitation. Seeliger has shown that the finely divided matter in circulation above the Sun within the obrit of the Earth which is revealed to us by the Zodiacal Light may be competent to produce the observed perturbation.

2. There is no question but that the English eclipse plates show displacements of the stars at the time of the eclipse (when the stars' rays passed close to the limb of the Sun) which are in accord with the displacement predicted by the theory. It is this fact upon which all the recent notice given to the theory rests. It must be remembered, however, that the total displacements are extremely small, and that the absolutely unavoidable errors of measurement amount to a considerable fraction of the entire displacements. The observers themselves were the first to point out this fact and to urge the desirability of repeating the observations at future eclipses to secure confirmation of the present results. Then it must be noted that the displacement, if thus confirmed, may be open to an alternative explanation. So eminent an astrophysicist as Professor Newall of Cambridge (Eng.) said at the joint meeting of the Royal Society and Royal Astronomical Society at which the eclipse results were formally announced, "I feel that the Einstein effect holds the day, but I do not yet feel that I can give up my freedom of mind in favour of another interpretation of the effects obtained. If Einstein had not existed, or had not predicted a deflection, we might have had a similar experiment made to test the presence of an extended atmosphere round the Sun, and we could have argued from the result back to the hypothesis. * * * * * I prefer to keep an open mind about interpretation".

3. "The shifting of spectral lines towards the red end of the sepctrum in case of light coming to us from stars of appreciable mass" has been very carefully tested in the case of the Sun. Here the magnitude of the shift required by the theory is from 50 to 100 times the error of modern measurement. In fact the predicted shift on plates taken with the powerful equipment on Mount Wilson is almost great enough to be detected, if it exists, by the unassisted eye. In spite

of this, Dr. St. John's investigations at Mount Wilson and Mr. Evershed's at the Kodaikanal Observatory, agree in giving negative results. *No displacement at all corresponding to the demands of the theory were detected.*

It thus appears that while two of the tests proposed by Einstein give favourable results, each of them *may* also be accounted for on the old Newtonian theory; and that the third—and this is precisely the one best adapted to accurate and repeated measurement—gives an unfavourable answer. Recalling once more Einstein's words, "If any deduction from it should prove untenable, it must be given up", we may concur in the opinion recently expressed by a number of prominent American physicists that the theory of relativity has not yet been established.—R. G. A. in *Publications of the Astronomical Society of the Pacific*,

EINSTEIN.

Twinkle, twinkle, little star,
How I wonder where you are!
'Cording to the new complaint,
Where you seem to be, you ain't.

If your light waves have a kink,
What, on earth, are we to think?
Are you here, or are you there?
You might be 'most anywhere.

Viewed from our terrestrial ball,
Some things are not there at all.
What, for instance, is Orion?
And the Bear? Perhaps, a lion!

Twinkle, twinkle, little star,
How I wonder where you are!
You are less than ever fixed;
I am more than ever mixed.

—From the *San Francisco Chronicle.*

STAR STUDY IN SCHOOLS

A powerful plea for the placing of astronomical study upon the school curriculum has been put forward by the British Astronomical Association. This recommendation is based on the high educational value of this science considered by itself, and also on the fact that its study can be, to some extent, combined with that of geography, mtahematics, and physics.

The association has appointed a special committee, consisting mainly of schoolmasters, to try to secure a definite place for astronomy in the school curriculum.

They propose to allow the hire of their slides, to send the journal of the association to the schools, and to admit the schoolmaster to attend their ordinary meetings.

They will also prepare a special series of lantern slides for educational purposes, and in many cases may lend the negatives in order that schools may make their own slides.

Whenever desired, they will be ready to give suggestions on such points as observation for small telescopes, naked-eye observations, text books, and occasional lectures.—*Press Despatch.*

OBSERVATION OF PLANETARY DETAIL.

Some interesting experiments on the ability of various persons to observe different kinds of planetary detail have been carried on at the University of Glasgow by Mr. T. L. MacDonald. Six students, having no previous knowledge of the Martian problem, were invited to copy a drawing of Mars by Antoniadi, as well as two other pictures, one being a photograph of the moon (for canal-like markings). No suggestion was made to them either as to what would be visible or the manner of drawing it. An examination of the results brings out the curious fact that practically without exception the observer who excelled most in noting either canals, lakes or gradations of shading either did not excel or actually fell below the average in respect to the others. Thus the student who saw the most canals saw the smallest number of shadings and nearly the smallest number of lakes, etc. Moreover, the distinguishing characteristic of each observer remains through all the sets of drawings with remarkable persistency. Mr. MacDonald formulates tentatively the rule that the work of all planetary observers may be classed according to sensitiveness to lines, spots and shadings; of which excellence in one is exclusive of excellence in the remainder. Thus it may be possible to classify observers by three coefficients, for canal, spot and shade sensitiveness, and correct their work in planetary drawings accordingly.—From *Scientific American.*

HOW HIGH IS THE AURORA?

Conflicting statements have been published concerning the altitude of the aurora. In the early part of the nineteenth century Farquharson, in Scotland, reported observing that auroras often illuminated the under surface of clouds, and in one case, from simultaneous observations at two stations, he found an altitude of only 4,000 feet. Trevelyan, from observations in the Shetland and Faroe Islands, concluded that the aurora often descends to 50 feet above sea-level. Parry, the Arctic explorer, reported seeing an auroral ray projected between his ship and the shore. Similarly Lemström, during the Swedish expedition to Spitsbergen in 1868, several times saw auroral lights projected between himself and the nearby mountains, and once found himself in the midst of an aurora. The modern method of measuring the height of the aurora is by means of simultaneous observations, visual or photographic, at two stations connected by telephone. Observations of this sort made at Godthaab, Greenland, some thirty years ago, and discussed by Paulsen have given heights for the lower edge of the aurora ranging from about 2,000 feet up to 42 miles, with an average of about 12 miles. Strange to say the more recent photographic observations of Störmer and those of Vegard and Krogness give very much greater altitudes. In Störmer's measurements of 1913, numbering about 2,500, only 21 gave an altitude under 56 miles, while the usual altitudes were 61 to 68 miles. The measurements reported by Vegard and Krogness showed only one aurora lower than 53 miles, while the greatest altitude observed was 205 miles. Can it be that there is a marked difference in the height of the aurora at different places on the earth? Or does the height differ from time to time with fluctuations in the intensity of electrical discharges from the sun, as suggested by Störmer?—From *Scientific American.* J. R. C.

NOTES AND QUERIES

PROFESSOR BARNARD'S VISIT TO TORONTO.

The recent visit of Professor E. E. Barnard, of the Yerkes Observatory, to Toronto is an astronomical phenomenon which deserves recording. He came on the invitation of the University of Toronto and the Royal Astronomical Society of Canada to lecture at the University; and he also addressed the Empire Club, an organization chiefly of "down-town" business and professional men who meet weekly for luncheon and to listen to some distinguished guest. The meeting of the Club was held at noon of March 25th in the King Edward Hotel, and the attendance was very large, many being unable to obtain accommodation. The room was darkened and Professor Barnard was able to illustrate his address, which was on "Photographing the Sky", with lantern slides. About five hundred listened to him with great interest.

The other meeting was in the evening of the same day and was held in the large auditorium of the Physics Building. There were about six hundred present, the room being crowded to its capacity. Indeed it is believed that this was the largest and most representative audience ever assembled in Toronto to hear an address on astronomy. The subject was "Astronomical Discovery by Photography", and of course it was illustrated by many of the lecturer's own inimitable slides.

Professor Barnard's visit has greatly extended the interest in astronomy in Toronto, and it will undoubtedly assist in the campaign now on to obtain a good astronomical observatory for the city.

A Fine Aurora.

There was an exceptionally fine aurora on the night of March 22nd. Seldom has such an exhibition been seen in these latitudes, and as it lasted practically all night many observed it. Accounts, somewhat abridged, of the display by three observers are given herewith. The observation that the great streamers were closely along the ecliptic, which is given by Mr. Hunter, was also mentioned to the writer by Mr. A. F. Miller. The moon and the three planets visible in the sky allowed the position of the ecliptic to be determined with considerable accuracy.

J. P. Henderson, Ottawa:

It was first observed about dusk or just after 7.00 p.m. Great pillars of flame seemed to extend right across the sky from the west to the east or south-east, but particularly strong in the west. Many other streamers were present in the sky but they were much stronger in the south and west than in the north and east; also a rather flat arc was present in the south. These variable streamers and waving curtains overhead continued practically throughout the night, but certain differences were noted as time went on. The playing flames were specially grouped or bunched overhead about 8.15 p.m., when there was a wonderful display of colours, red and purple and pink, besides the prevailing green. (I did not see this display but did see a similar one later—was informed of this one.) There was somewhat less activity after this till about 10.00 p.m., when there was continually present in the north one or more arcs, from which curtains would spring and wave toward the south and west—very little in the east. The smaller streamers which earlier in the evening had continually reminded one of comets with great bushy tails now became great masses and quivering beams of white or greenish-coloured flame as they periodically brightened overhead, and, in spite of the street lights, appeared to illuminate the surroundings with a peculiar glow. Every two or three minutes a beam would brighten up to great intensity, wave for a quarter of a minute or so and then rapidly die away again and be lost in the general auroral glow of the sky. At 10.20 p.m. I saw perhaps the most wonderful display of the whole gorgeous spectacle when directly in the zenith there appeared curtains waving and all bunched together as if suspended from an immense height and hung directly overhead. At first showing only a greenish shade, they became tipped at their lower edges—really the brightest parts—with a beautiful purple, and because of so many waving together the purple was often all mixed up with the greenish part, but there seemed no doubt that really only the lower and brighter sections of each curtain was purple. This lasted less than a minute, and after it the periodic auroral streamers did not seem to attain such intense brightness as they did before. The aurora continued during the night.

A. F. Hunter, Toronto:

My attention was attracted by streamers near the new moon at 7.35 p.m E.S.T. and I went outdoors to investigate. There was, at that time, a well-formed corona overhead, with focus on the star Delta Geminorum. Streamers were to be seen everywhere, but mainly along the ecliptic. The focus was on Pollux (Beta Geminorum), at 7.48 p.m., E.S.T., as nearly as I could observe it. At the same minute there were vivid rose and green tints to be seen, and dancing streamers for a few minutes afterwards. At 8 p.m. the focus of the corona, by the rotation of the earth, was about two degrees east of Pollux. Some curtain forms were to be seen in the east at this time.

Altogether, the display was a good one, all the prominent features of the first order being present, viz., a well-defined corona, coloration, dancing, and outbreaks over the entire sky; in other words, it was a good all-round display, although each of the features is sometimes surpassed in quantity.

The feature of the display that could rarely be duplicated was its occurrence at the time of the equinox (March 22nd) from which we could observe directly that streamers coming from the position of the sun below the horizon coincided with the ecliptic, and the main display of streamers adhered to the ecliptic across the entire sky.

J. Edward Maybee, Port Credit, in "The Globe":

The point about it that struck me most forcibly was the splendid display of colour noticeable at my point of observation at Port Credit. While green predominated, as is quite usual in auroras, at times there appeared quite brilliant flashes of rosy-coloured light. In fact, it appeared at times as though almost all the colours of the spectrum were visible. At times, in proximity to a brilliant band of green would appear a streak of dull purple, a shade approximately complementary to the green. This may have been an effect of contrast, and was noticeable quite distinctly and pointed out by me to others at about 10 o'clock at night, though I had observed it at different times during the evening. Another feature of the display, particularly as seen between 7.30 and 8 o'clock, was that the rays and wavy curtains of light appeared to be very clear, so that I almost expected to see, as has been before observed, parts of the aurora between my station of observation and some distant object. However, I could not say that this was the case with the present display.

C. A. C.

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